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Cooperative State
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and Extension Service

Competitive Research
Grants and Awards
Management

NRI Annual Report: Fiscal Year 1998

National Research Initiative Competitive Grants Program



"Knowledge for Tomorrow's Solutions"

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This annual report and other NRI materials such as *Abstracts of Funded Research*, the *1999 NRI Program Description*, *NRI Research Highlights*, and *NRI Cover Stories* are available on the NRI home page (www.reeusda.gov/nri). For more information about the NRI, write or call the National Research Initiative Competitive Grants Program, Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, Mail Stop 2241, 1400 Independence Ave., SW, Washington, DC 20250-2241; 202/401-5022; nricgp@reeusda.gov

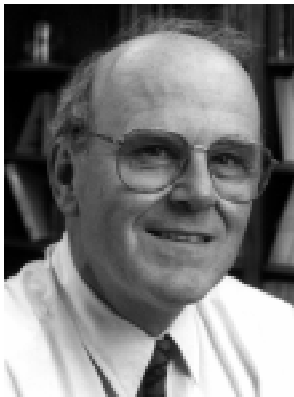
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Message From the NRI Chief Scientist



University of Missouri Photo

Dear Colleagues:

The National Research Initiative (NRI) Competitive Grants Program uses a competitive peer-review process to award grants supporting research in the biological, environmental, physical, and social sciences on regional and national problems relevant to agriculture, food, forestry, and the environment. The ultimate goal of this research is to ensure that U.S. agriculture and forestry are sustainable and globally competitive. Competition for NRI research funds is open to researchers at all U.S. academic institutions, Federal research agencies, and private and industrial organizations as well as to individual researchers with no institutional affiliation.

In 1998, the U.S. Department of Agriculture celebrated 20 years of support of agricultural and forestry research through competitive grants. An initial 1978 appropriation of \$14 million, administered by the Competitive Research Grants Office, was directed primarily at plant science and human nutrition. New areas were added later, and in 1991, the entire competitive grants program was expanded with the creation of the NRI and a \$73 million appropriation.

The intent of the 1990 Farm Bill, as expressed in its original authorizing language, was that funding for the NRI would increase incrementally to \$500 million over 5 years. However, annual appropriations have hovered around \$100 million since 1992. This level of support has permitted funding of approximately 700 proposals each year, but generally with reduced budgets. In 1998, for example, 699 awards totaling \$88,106,761 were made from 28 different programs. The average award for new standard research projects was \$146,666 for 2.3 years—substantially less than the amount requested (an average of \$244,051 for 2.7 years) by these successful proposals.

Despite the NRI's small budget, the modest level of awards, and the fact that agricultural research encompasses a broad range of topics, from rural sociology to genomics, the NRI has been remarkably successful in providing a knowledge base to underpin applied research. Individuals wishing to learn more about NRI-funded research may wish to read *NRI Research Highlights*, a series of factsheets featuring successful NRI-funded research projects and their potential impact on U.S. agriculture, and *NRI Cover Stories*, a series of flyers depicting NRI-funded research that has been featured on the covers of prominent peer-reviewed scientific journals. Both are available on the NRI home page (www.reeusda.gov/nri).

I hope the information in this report will provide you with insight into how the NRI operates within the USDA, as well as a brief overview of some of the research that the NRI recently has been supporting. As Chief Scientist, I am proud of the accomplishments of the NRI and of the NRI staff, who—despite their small numbers—do an excellent job of administering the program. I also thank the many fine scientists who contribute to the mission of the NRI through their participation in the peer-review process.

A handwritten signature in black ink, reading "R. Michael Roberts". The signature is stylized and cursive.

R. MICHAEL ROBERTS
NRI CHIEF SCIENTIST

The National Research Initiative: Overview

USDA's National Research Initiative was established in 1991 in response to recommendations outlined in *Investing in Research: A Proposal to Strengthen the Agricultural, Food and Environmental System*, a 1989 report by the National Research Council's (NRC) Board on Agriculture. This publication called for increased funding of high-priority research, funded by USDA through a competitive peer-review process, directed at

- Increasing the competitiveness of U.S. agriculture.
- Improving human health and well-being through an abundant, safe, and high-quality food supply.
- Sustaining the quality and productivity of the natural resources upon which agriculture depends.

Continued interest in and support of the NRI is reflected in a second NRC report, *Investing in the National Research Initiative: An Update of the Competitive Grants Program of the U.S. Department of Agriculture*, published in 1994. In 1998, the NRC began a comprehensive evaluation of the NRI's progress and accomplishments. A report based on this evaluation is anticipated in 1999.

Competitive Review Process

The NRI competitive review process encourages innovative ideas that are likely to open fundamentally new research approaches to enhancing agriculture, food, forestry, and the environment. A proven mechanism for stimulating new scientific research, the process increases the likelihood that investigations addressing important, relevant topics using well-designed and well-organized experimental plans will be funded. Each year, panels of scientific peers meet to evaluate and recommend proposals based on scientific merit, investigator qualifications, and relevance of the proposed research to U.S. agriculture.

At least 10 percent of NRI funds support Agricultural Research Enhancement Awards. These awards enhance the U.S. agricultural research system through funding of postdoctoral fellowships

and research by new investigators as well as through Strengthening Awards.

Strengthening Awards include the following categories: Research Career Enhancement Awards, Equipment Grants, Seed Grants, and Strengthening Standard Strengthening Projects. These grants fund researchers at small and mid-sized institutions with limited institutional success or in states and other entities that are part of the Experimental Program for Stimulating Competitive Research (EPSCoR).

The NRI encourages multidisciplinary research, which is needed to solve complex problems, and seeks to initiate research in new areas of science and engineering that are relevant to agriculture, food, forestry, and the environment. The NRI also supports scientific conferences to facilitate the exchange of information necessary to achieve the most rapid advances in these areas. Both mission-linked and fundamental research are supported by the NRI. Mission-linked research targets specific problems, needs, or opportunities. Fundamental research, the quest for new knowledge about agriculturally important organisms, processes, systems, or products, opens new directions for mission-linked research. Both mission-linked and fundamental research are essential to the sustainability of agriculture.

Policy

A Board of Directors, chaired by the USDA Under Secretary for Research, Education, and Economics (REE), provides oversight of NRI policy. Board members include the Administrators of the four agencies comprising the REE Mission Area—the Cooperative State Research, Education, and Extension Service (CSREES), the Agricultural Research Service, the Economic Research Service, and the National Agricultural Statistics Service—as well as the Deputy Chief for Research of the Forest Service and the NRI Chief Scientist. The Deputy Administrator of CSREES' Competitive Research Grants and Awards Management Division serves as the Board's Executive Officer.

The Board of Directors oversees NRI policy by providing comments to the CSREES Administrator

on the annual *NRI Program Description*; considering the recommendations made by the National Agricultural Research, Extension, Education, and Economics Advisory Board; identifying issues of importance to the NRI; providing a forum on future directions of the NRI; and fostering communication across relevant USDA research agencies regarding NRI programs and procedures.

Identification of Research Priorities

Setting research priorities is an important means of facilitating the scientific and technological advances needed to meet the challenges facing U.S. agriculture. Congress sets the basic budgetary framework for the programs of the National Research Initiative by providing funds in six priority categories (see section on Authorization, below). Members of Congress also make recommendations for the scientific and programmatic administration of the NRI through appropriation language and through their questions and comments during Congressional hearings.

Input into the priority-setting process is sought from a variety of NRI customers and stakeholders. The scientific community provides direction for the NRI through the research proposals it submits each year as well as through the research proposal evaluations and funding recommendations of individual scientific peer-review panels.

NRI scientific staff play an important role in providing continuity of programmatic and scientific administration from year to year. Staff members attend scientific and professional meetings to stay current on scientific trends that need to be reflected in the *NRI Program Description* and in the coordination of priority-setting with other Federal agencies. National Research Initiative staff also participate in meetings with representatives of key commodity groups and other user groups to discuss these stakeholders' current research priorities, learn ways the NRI can assist in meeting their needs, and solicit comments and suggestions on NRI research priorities.

Input from several coalitions has proved an important source of information. NRI staff members meet with groups such as the Institute of Food

Technologies, CROPS99, CO-FARM, C-FARE, and the Animal Agriculture Coalition to gain a broad perspective on current research needs and priorities.

The NRI Chief Scientist, the Deputy Administrator of the Competitive Research Grants and Awards Management unit, and NRI scientific staff are responsible for assimilating the input of diverse stakeholder groups into a program description that will solicit the highest-quality proposals to meet the needs of U.S. agriculture. The NRI research areas, which are evaluated and updated each year, are included in the *NRI Program Description* issued annually.

The *NRI Program Description* is accessible to universities, Federal research laboratories, private research organizations, and individual scientists both in printed form and on the Internet via the NRI home page. In addition, the NRI receives comments on its programs from academic administrators, other staff members, and scientists from partner universities; the Experiment Station Committee on Policy; and the research administrators of the 1890 land-grant institutions.

Authorization

In the legislation authorizing establishment of the NRI, Congress defines high-priority research as basic and applied research that focuses on both national and regional research needs (and methods for technology transfer) in the following areas:

- Plant Systems
- Animal Systems
- Nutrition, Food Quality, and Health
- Natural Resources and the Environment
- Engineering, New Products, and Processes
- Markets, Trade, and Policy

The authorizing legislation requires that, as appropriate, grants be consistent with the development of systems of sustainable agriculture. Congress further has specified that no less than 30 percent of funds be used to support multidisciplinary team research; no less than 40 percent be used for mission-linked research, and no

less than 10 percent be used to strengthen the research capacity of individuals and institutions.

Program Implementation

The *NRI Program Description* is distributed widely within the scientific community and among other interested groups. The fiscal year (FY) 1998 *NRI Program Description*, published in the August 6, 1997 *Federal Register*, identified 26 research programs within the following eight major research areas:

- Natural Resources and the Environment
- Nutrition, Food Safety, and Health
- Animals
- Pest Biology and Management
- Plants
- Markets, Trade, and Rural Development
- Enhancing Value and Use of Agricultural and Forest Products
- Agricultural Systems Research

A total of 2,579 research proposals were considered for funding in FY 1998. Twenty-nine peer panels reviewed and ranked the proposals, evaluating them on scientific merit, the qualifications of proposed project personnel, the adequacy of the proposed facilities, and the relevance of the proposed project to long-range improvements in—and the sustainability of—U.S. agriculture.

Each peer panel was composed of individuals with the expertise required to review each proposal thoroughly and fairly. Proposals for Postdoctoral Fellowships, New Investigator Awards, and Strengthening Standard Research Projects were reviewed within the specified research program area. Proposals for Research Career Enhancement Awards, Equipment Grants, and Seed Grants were reviewed as a group.

Criteria for the selection of panel members included knowledge of the relevant scientific discipline, educational background, experience, and professional stature within the scientific community. The membership of each panel was carefully balanced to reflect diversity in geographical region, type of institution, type of position (academic, including rank; Federal; industry; or other), and gender and minority status (see Table 1).

Table 1. Characteristics of NRI Peer Panels, FY 1998

Geographical Region	Number	Percentage
North Central	96	33.0
Northeast	60	20.6
South	69	23.7
West	66	22.7
Type of Institution		
Land-grant	200	68.7
Public/private	34	11.7
Federal	36	12.4
Industry/Other	21	7.2
Type of Position		
Assistant professor	49	16.8
Associate professor	81	27.8
Professor	98	33.7
Federal	36	12.4
Industry	16	5.5
Other	11	3.8
Gender/Minority Representation		
Nonminority males	187	64.3
Nonminority females	69	23.7
Minority males	31	10.7
Minority females	4	1.4

Additional expertise was brought to proposal evaluation by a number of scientists and other experts, representing a wide variety of fields, who conducted *ad hoc* reviews. These reviews provided the additional expertise that made it possible to select the highest quality, most meritorious proposals for funding.

More than 9,000 scientists contributed their time and expertise to the NRI proposal evaluation process in 1998. Participation in the panels and in writing *ad hoc* reviews provided many individuals the opportunity to gain experience in the review process and to become more familiar with the nature of the science supported by the NRI. The pool of *ad hoc* reviewers also provided a resource from which future panel members may be selected.

At the conclusion of the review process, a summary of the panel evaluation and the written reviews were forwarded to the submitting investigators, providing them with critical assessments of their proposed research by recognized leaders in the appropriate fields. The reviewers' comments and suggestions also were important for purposes of refining the proposals for future resubmission.

Continuing a practice begun in 1993, nontechnical summaries describing each funded research project were published in 1998 as *Abstracts of Funded Research* and submitted to the House and Senate Agriculture Appropriations Committees. This publication is also available via the Internet on the NRI home page.

Grantsmanship Workshops

NRI program staff conducted a number of workshops in FY 1998 to increase applicants' and administrators' understanding of the philosophy and procedures of the NRI competitive review process. In October 1997, staff held a grant-writing workshop in Philadelphia as part of its ongoing practice of conducting a major grant-writing workshop annually in one of the four regions (North Central, Northeast, South, and West) of the United States. The Philadelphia workshop, co-sponsored by the NRI and the University of Delaware, focused on guidelines for preparing proposals, individual program descriptions, and recent funding statistics.

In addition, the NRI conducted individualized workshops at EPSCoR institutions, including the University of Maine; at the National Conference of Historically Black Colleges and Universities; and as part of the Rapid City Workshop for Tribal Colleges. NRI program staff also conducted mini-workshops at national meetings of scientific and/or professional societies, for regional research groups, and for other audiences, including Congressional Science Fellow groups, the National EPSCoR Conference, and the Forest Service Forest Products Laboratory.

Funded Research

In FY 1998, a total of 2,579 proposals were submitted to the NRI—approximately 9 percent fewer than the number submitted in 1997 and about 16 percent fewer than the number submitted in 1996. A total of \$547,107,296 in funding, also lower than in previous years, was requested in FY 1998. Six-hundred ninety-nine awards—totaling \$88,106,761—were made in FY 1998 (see Table 2).

The success rate (in terms of number of proposals funded and excluding conferences, supplements, and continuing increments of the same grant) was 25 percent, which is slightly higher than the comparable figures for 1997 and 1996. The average grant award for regular research programs (excluding Research Career Enhancement Awards, Equipment Grants, and Seed Grants) was \$136,065, with an average duration of 2.2 years. (For FY 1997, these figures were \$133,379 for 2.6 years.) If the funding of conferences, continuing increments, and supplements are excluded, the average award for new standard research projects in FY 1998 was \$146,666 for 2.3 years. (For FY 1997, the comparable figures were \$141,834 for 2.6 years.)

The NRI provided funds totaling \$252,332 in partial support of 37 conferences in FY 1998. These conferences brought scientists together to identify research needs, update one another on research information, and/or advance an area of research important to U.S. agriculture.

In FY 1998, the NRI provided funds totaling \$15,462,324 in Agricultural Research Enhancement Awards. This support included Postdoctoral Fellowships, New Investigator Awards, and Strengthening Awards (see Table 3, page 6).

Due to a shortage of funds, the NRI did not offer the Forest/Range/Crop/Aquatic Ecosystems Program in FY 1998. This program is being offered in FY 1999.

Table 2. NRI Funding Allocations,¹ FY 1998

Research Area/Program	Number of Grants	Award	Research Area/Program	Number of Grants	Award
Natural Resources and Environment			Plants		
Plant Responses to the Environment	33	\$4,188,020	Plant Genome	28	5,193,172
Forest/Rangeland/Crop/Aquatic Ecosystems ²	1	17,678	Plant Genetic Mechanisms	36	4,251,502
Water Resources Assessment and Protection	16	2,923,500	Plant Growth and Development	45	5,005,000
Soils and Soil Biology	21	4,139,678	Nitrogen Fixation/Nitrogen Metabolism	20	1,883,250
Total	71	11,268,876	Photosynthesis and Respiration ⁴	19	2,192,000
			Total	148	18,524,924
Nutrition, Food Safety, and Health			Markets, Trade, and Rural Development		
Improving Human Nutrition for Optimal Health	24	3,787,105	Markets and Trade	22	1,717,000
Ensuring Food Safety	23	2,901,442	Rural Development	16	1,474,518
Total	47	6,688,547	Total	38	3,191,518
Animals			Enhancing Value and Use of Agricultural and Forest Products		
Animal Reproductive Efficiency	30	4,308,111	Food Characterization/Process/Product Research	19	2,867,318
Animal Health and Well-Being	60	9,728,906	Nonfood Characterization/Process/Product Research	17	2,274,459
Animal Genetic Mechanisms and Gene Mapping	20	3,231,142	Improved Utilization of Wood and Wood Fiber	19	1,956,547
Animal Growth, Development, and Nutrient Utilization	27	3,629,585	Total	55	7,098,324
Total	137	20,897,744	Other		
Pest Biology and Management			Agricultural Systems	9	1,953,206
Entomology and Nematology	46	5,553,000	Strengthening Programs	77	3,410,494
Nematology ³	2	145,000	Joint Program on Collaborative Research in Plant Biology (Interagency) ³	2	135,507
Plant Pathology	36	4,572,686	Terrestrial Ecology and Global Change (Interagency)	3	898,000
Biologically Based Pest Management	15	1,890,000	<i>Arabidopsis thaliana</i> Genome Sequencing Project (Interagency) ⁵	1	200,000
Weed Biology and Management	11	1,380,000	Interagency Metabolic Engineering Program	1	298,935
Total	110	13,540,686	Total	93	6,896,142
			Grand Total	699	88,106,761

¹These tables vary slightly from those provided in documents supporting the President's annual budget request to Congress. The awards in this table are categorized by program area (to which proposals are submitted and reviewed) rather than by their relationship to appropriated budgetary lines.

²Supplementary award.

³Awards made only as continuing increments of awards from prior years.

⁴Does not include one award for \$4,000 made with returned FY 1996 funds.

⁵Awarded through an interagency transfer to the National Science Foundation.

Table 3. Agricultural Research Enhancement Awards, FY 1998

Type	Number of Grants	Award
Postdoctoral Fellowships	24	\$2,125,586
New Investigator Awards	40	4,966,426
Strengthening Awards		
Research Career Enhancement Awards	9	597,532
Equipment Grants	30	935,593
Seed Grants	38	1,877,369
Standard Strengthening Research Projects	39	4,959,818

Crosscutting Areas

A number of research topics of major importance to USDA involve several research areas or programs. NRI support for these crosscutting program areas in FY 1998 is indicated in Table 4.

The data show the total amount of funding from all research areas for a specified research topic. For example, the Water Quality area includes projects from the Water Resources Assessment and Protection Program as well as projects from other programs relevant to water quality such as Soil and Soil Biology. The Integrated Pest Management area includes projects funded from the programs on Biologically Based Pest Management; Entomology and Nematology; Plant Pathology; and Weed Biology and Management. The \$6.3 million funding allocation for sustainable agriculture represents projects identified from many NRI programs, including the Agricultural Systems Research Program, as directly relevant to sustainable agriculture. This figure is probably an underestimate since, in a broad sense, virtually all research supported by the NRI is potentially germane to sustainable agriculture.

Table 4. Crosscutting Program Areas, FY 1998

Research Topic	Number of Grants	Award
Plant Genome	167	\$10,380,101
Forest Biology	29	2,791,174
Global Change	52	6,403,295
Sustainable Agriculture	48	6,294,327
Animal Genome	23	3,664,345
Animal Health	82	11,987,586
Water Quality	19	2,708,178
Food Safety	41	4,870,348
Integrated Pest Management	77	9,062,874

Research Dimensions

As noted earlier, research programs can be examined from perspectives such as type of investigation (fundamental or mission-linked) and organization of research approach (single discipline or multidisciplinary). NRI funding in FY 1998 for these categories is shown in Table 5.

Table 5. Dimensions of NRI Research, FY 1998

Type of Research	Amount of Support	Percent
Fundamental	\$51,004,007	58.0
Mission-linked	36,906,754	42.0
Multidisciplinary	36,640,493	41.7
Single discipline	51,262,268	58.3

Interagency Research

NRI program directors work closely with their research-funding counterparts in other Federal agencies to avoid duplication and maximize interagency cooperation. An example of cooperation is seen in the research that NRI funds jointly with other Federal agencies, including:

- The Interagency Metabolic Engineering Program, established in 1998 with the Department of Energy (DOE), the National Science Foundation (NSF), the Department of Commerce, and the Department of Defense.
- The Terrestrial Ecology and Global Change Program, established in 1995 with DOE, the Environmental Protection Agency, the National Aeronautics and Space Administration, the National Oceanographic and Atmospheric Administration, and NSF.
- The *Arabidopsis thaliana* Genome Sequencing Project, established in 1995 with NSF and DOE.
- The Joint Program on Collaborative Research in Plant Biology, established in 1992 with NSF and DOE.

Each collaborative research program issues a single request for proposals, and agency representatives work together to assemble a panel of scientific peers to identify the most meritorious proposals. From this group, representatives of each agency select proposals that are the most germane to the mission of that agency. Thus, the NRI is able to attract researchers from a wide applicant pool to projects of importance to agriculture.

Presidential Early Career Award for Scientists and Engineers

In FY 1998, Dr. Krishna K. Niyogi of the University of California, Berkeley, received a Presidential Early Career Award for Scientists and Engineers in recognition of his research on nonphotochemical quenching. The award, for which he was nominated by the NRI, honors scientists and engineers who show exceptional potential for leadership at the frontiers of knowledge during the 21st century.

A 1998 recipient of an NRI New Investigator Award, Niyogi currently is Assistant Professor with the Department of Plant and Microbial Biology at the University of California, Berkeley. He received training as a biologist, biochemist, and molecular biologist at the University of Cambridge and the Massachusetts Institute of Technology and has held a research appointment at the Carnegie Institute of Washington.

Niyogi's work is contributing new insights into the mechanism by which plants transform excess light energy to heat, thereby providing protection of mechanisms involved in photosynthesis. His work also is furthering scientific understanding of plant adaptation to growth under high light conditions.

The National Research Initiative: Achievements

In FY 1998, NRI-funded research provided important insights into a number of research questions involving agriculture, food, forestry, and the environment. This section highlights examples of fundamental and mission-linked research targeted at important problems in these areas. The research examples are organized according to the five broad outcomes outlined in CSREES' *Government Performance and Results Act Strategic Plan*.

Outcome 1: An agricultural production system that is highly competitive in the global economy

Control of plant growth responses by steroids.

Scientists at the Salk Institute in La Jolla, California, have discovered a mutation in the model plant *Arabidopsis* that results in abnormal growth responses to light. The key gene, which has been cloned, encodes an enzyme involved in the biosynthesis of a group of plant steroids, the brassinosteroids. Normal growth responses can be restored by application of these steroids to the mutants.

Steroid hormones are well-known hormones in animals, but their role in plants has been more controversial. This discovery not only confirms the importance of steroid hormones outside the animal kingdom, but is likely to point the way toward new methods of controlling the growth and development of major crop species.

Altering the biophysical properties of vegetable

oils. Many plants accumulate seed reserves as oils composed of triacylglycerols, which constitute important sources of food and industrial products such as soaps, detergents, lubricants, and plastics worth an estimated total of \$25 billion worldwide. The value of these oils depends on their biochemical and physical properties, which in turn are related to the degree of unsaturation of their fatty acid components. With NRI funding, a research group at Washington State University has cloned the genes for several key desaturases from *Arabidopsis*. These genes are now being introduced into crop plants to "design" novel vegetable oils.

Directed production of short-chain fatty acids

in plants. An NRI-supported group at Oregon State University is cloning the genes responsible for synthesis of medium-chain fatty acids, which have sig-

nificant commercial value, from wild plants of the genus *Cuphea*. These genes, when introduced into *Arabidopsis*, increase the production of shorter-chain fatty acids. Such discoveries are likely to lead to an increased supply of more useful agricultural products.

Evolution of pathogen resistance genes in lettuce. Researchers at the University of California, Davis, are studying ways that plants evolve to keep pace with the emergence of virulent new pathogens. Lettuce, a vegetable crop plant worth \$100 million per year, is particularly susceptible to downy mildew.

The Davis group has mapped the major resistance genes in lettuce. These genes occur in large clusters and diversify rapidly by duplication and accumulation of mutations that change amino acids preferentially. Understanding the processes that generate new resistance genes in this manner provides the opportunity to imitate and accelerate such events in the laboratory and to find similar genes in wild plant populations that could be used to generate pathogen-resistant crop plants.

Control of ethylene responses in tomatoes. Ethylene is a gaseous plant hormone that regulates many important aspects of plant growth and development, including fruit ripening. A research group at the University of Florida has found that a mutation in a tomato variety whose fruit never ripens is caused by a molecule that "senses" ethylene. This discovery will open the way to introducing mutant genes into plants, thus slowing or accelerating ethylene responses and allowing more effective control of fruit ripening.

Virulence of the corn stalk rot fungus. The anthracnose fungus *Colletotrichum graminicola* causes fungal stalk rot, a major disease in corn. Researchers at the University of Kentucky are attempting to identify genes that are important in the fungus' ability to colonize and rot corn pith. Utilizing detached stem segments from corn plants, the scientists have developed a bioassay for anthracnose stalk rot. This bioassay is likely to be valuable to corn breeders, who will be able to use it to prescreen germplasm in the laboratory.

The researchers have used the bioassay to screen isolates of *C. graminicola* and have found that one

of the isolates is consistently less aggressive than the others in its ability to rot corn pith. They plan to create several thousand *C. graminicola* mutants and to screen them with their new bioassay in order to identify genes involved in fungal colonization and in the ability of the fungus to rot corn pith. This information could aid in the design of more effective ways to control the disease.

Vasoactive intestinal polypeptide (VIP) and egg-laying in turkeys. It has become increasingly difficult to identify and manage nesting turkey hens in commercial operations that typically consist of 20,000–30,000 hens per flock. Commercial turkey breeders currently rely on management procedures to extend the egg-laying period and discourage incubation or nesting behavior.

Using funds from the NRI, investigators at the University of Minnesota have discovered that elevated circulating concentrations of the hormone prolactin inhibit ovarian function, stimulate nesting behavior, and decrease egg production. Additional studies have revealed that the brain produces vasoactive intestinal peptide, the only known physiological stimulator of prolactin in turkeys.

Scientists have developed a strategy to reduce circulating concentrations of prolactin by immunizing turkey hens against VIP. Results of two studies indicate that such immunizations can increase egg production by 36 percent. The gene that encodes turkey VIP recently has been isolated, and investigators are seeking ways to generate large quantities of pure VIP through genetic engineering and recombinant DNA technology—thus providing the turkey industry with an affordable tool to discourage nesting behavior and increase egg production.

Estrogen and programmed development of the uterus. Embryonic mortality is the major factor limiting reproductive efficiency in swine. Loss of viable embryos may occur due to failure of the uterine environment to support embryonic development. Research conducted with NRI funds at Auburn University is providing new information on the role of estrogen receptors in uterine wall development, the consequences of inappropriate estrogen exposure for patterns of uterine organization, and the capacity of uterine tissues to support embryo survival in the pig.

During the first 14 days of postnatal life, expression and activation of uterine receptors for estrogen are required for normal development and optimum function of the uterus for future pregnancies. The Auburn researchers have found that exposure to environmental pseudoestrogens or xenobiotics during early postnatal life, through direct effects on uterine cells containing estrogen receptors, can affect reproductive efficiency in the pig and other mammals. These discoveries may have implications for human health, as compounds with estrogenic properties (“endocrine disruptors”) have been implicated in a number of developmental disorders in humans and rodents.

Protection against rotaviruses in piglets. Porcine rotaviruses cause severe gastroenteritis in swine after the piglets have been weaned, with long-term consequences—including growth retardation—in survivors. Researchers at the University of Illinois have identified a receptor on the cells of the intestinal lining that binds the virus and prevents infection. This receptor is a glycolipid (a ganglioside), which is normally present in neonatal swine. After weaning, however, the number of receptors decreases, rendering the piglet susceptible to group A rotavirus. It is now hoped that a better understanding of the receptor structure can be used therapeutically to treat outbreaks of infection in swine production facilities.

Outcome 2: A safe and secure food and fiber system

Dietary influences on E. coli infections of cattle. The contamination of beef and dairy products with the highly virulent *E. coli* 0157:H7 continues to compromise food safety and to pose a major health problem worldwide. It is known that healthy cattle can harbor this pathogen transiently in their gastrointestinal tracts, but the conditions that allow *E. coli* 0157:H7 to colonize the gut and build up in numbers sufficient to pose a threat to food safety are unknown.

A study by NRI-supported researchers at the University of Idaho has shown that an animal’s diet influences the duration of infection as well as the quantity of the bacteria in feces. This knowledge potentially can lead to on-farm guidelines that reduce the number of infected animals entering the

human food chain. An unexpected and important finding of this study was that *E. coli* 0157:H7 can survive in fecal material in the environment for more than 2 years, thereby providing a reservoir of the pathogen for reinfection.

***E. coli* resistance to acid pH.** Researchers at the University of Wisconsin have investigated two proteins whose presence is correlated with the ability of strains of *E. coli* 0157:H7 to withstand low pH. One of them, CspE, is probably a DNA-binding protein. Because *E. coli* 0157:H7 can cause infection even when present in contaminated food in small numbers, part of its success as a pathogen may lie in its ability to escape destruction in the environment of the stomach. Hence, CspE and other proteins that probably confer tolerance are candidates for further study.

Determining safe cooking procedures. Although it has been scientifically established that the color of meat is not a reliable indication of cooking adequacy, no accurate benchmark for food safety temperatures has been identified. Researchers at Michigan State University are investigating triose phosphate isomerase, a relatively thermal-stable enzyme, as a possible time-temperature integrator to measure the thoroughness with which beef has been cooked.

Under development is a simple immunoassay that will distinguish the normal folded state of the enzyme from its heat-denatured form. The test will serve as an indicator of the efficacy of cooking temperature and duration that is more specific to the pathogens being tested.

Outcome 3: A healthy, well-nourished population

Basis of the nutritional value of fish oils. There is growing public and scientific interest in the potential therapeutic benefits of supplementing human diets with omega-3 polyunsaturated fatty acids such as those found in fish oils. Many over-the-counter products containing these compounds are being touted for treatment or prevention of an array of chronic human diseases. Little is known, however, about the behavior of omega-3 fatty acids in the body or, indeed, whether the compounds are entirely benign.

So far, the consensus among scientists is that omega-3 fatty acids influence the production of cytokines—chemical messengers that control the body's immune system. NRI-funded research at the University of Missouri has shown that mice infected with *Listeria monocytogenes* produce much lower levels of the inflammatory cytokines interleukin-12 and interferon-g when they are fed a diet rich in fish oils. The mice also were found to have fewer interferon-g receptors on their immune cells. This research may help explain the apparent beneficial effects of omega-3 fatty acids on a number of autoimmune and other inflammatory disorders in which interferon-g production becomes elevated.

Porcine somatotrophin administration for leaner pigs. Over the past decade, Pennsylvania State University scientists have developed a biotechnological method for increasing young pigs' rates of overall growth and muscle growth and for reducing fat deposition in the animals. The researchers, supported in part by the NRI, have discovered that administration of somatotrophin increases pigs' growth rate by 10–15 percent, enhances muscle growth by as much as 50 percent, reduces fat deposition by 50–70 percent, and improves production efficiency by as much as 30 percent. The method also represents an advantage in reducing environmental pollution because more nutrients are used for growth and fewer are excreted into the environment.

These research findings will help the swine industry produce leaner animals, improve the efficiency of swine production, and provide greater economic returns to swine producers. The development of a biotechnological approach to reducing fat also can benefit health-conscious consumers wishing to include more lean pork in their diets.

Reducing mammary gland infections in dairy cows. NRI-supported research at the University of Illinois has shown that cows increase their production of lactoferrin, a major nonspecific disease-prevention component and source of iron in milk, at the end of the milking period. This finding may lead to ways to increase lactoferrin production, thereby providing protection to the mammary gland both prior to and during the cow's dry period. If such a "natural" approach can be developed, the need for dry-cow antibiotic treatments will be much

reduced, and a better quality milk product may be achieved.

New methods of assessing vitamin A status.

Vitamin A inadequacy, a major health problem throughout the world, can lead to increased rates of infection, reproductive disorders, and, in severe cases, blindness. Current methods of measuring the vitamin A status of humans remain inadequate, and improved assessment methods are needed.

NRI-supported scientists at Iowa State University have developed a new response test based on the rate of hydrolysis of retinoyl β -glucuronide, a naturally occurring metabolite of vitamin A. The test has been validated in rats and shows promise for human use. The Iowa State scientists also have developed a useful chromatographic method of assessing patients' nutritional status by separating vitamin A, vitamin E, and various carotenoids in blood serum.

Outcome 4: Greater harmony between agriculture and the environment

Regulating carbon in forests. Nutrient- and pesticide-rich agricultural runoff has been implicated as a possible cause of declines in amphibian populations and in the extinction of some species. However, very little research has been conducted on the potential consequences of the loss of amphibians to ecosystem functioning.

With NRI funding, researchers at the Edmund Niles Huyck Preserve, Inc., and the Biological Research Station in New York State are studying the effects of the presence and absence of salamanders in a Northeastern hardwood deciduous forest ecosystem. The researchers have found that environments containing salamanders have significantly fewer invertebrates, particularly beetle and fly larvae, compared to environments that exclude salamanders. The scientists also have noted a consequent reduction in the rate of decomposition of litter, indicating that presence or absence of salamanders and possibly predators in general may alter the carbon dynamics of a forested ecosystem significantly.

Immobilizing metal contaminants on soil. Contamination of soil and water with potentially toxic

levels of metals—including cadmium, copper, lead, and nickel from agricultural, industrial, and municipal sources—is a national concern in terms of crop production as well as human and animal health. Some soils can retain such metals on the surface of their particles, thereby decreasing contaminant mobility. However, the mechanisms that lead to metal retention on soil particles are unknown.

With NRI funding, scientists at the University of Delaware are studying the retention of nickel on soil particles. Employing x-ray absorption, fine structure spectroscopy, and scanning force microscopy, they have shown that nickel and aluminum hydroxide form a surface layer on soil particles in a matter of minutes—rather than over a period of days, as was previously believed. They also have found that the release of the nickel from the soil particles is minimal if the soil remains undisturbed for at least 6 months. The formation of metal hydroxide precipitates on soil surfaces and their gradual stabilization over time could suggest an important new method of removing soil contaminants at polluted sites.

Interdependency of soil and plant communities.

The effects of the soil community on plant composition and diversity are virtually unknown, as are the effects of plants on the soil bacterial and fungal community. Although an association between (1) mineral nutrition and nutrient cycling in plants and (2) bacterial and fungal roles in decomposition is widely assumed, no direct relationships have been documented.

NRI-supported research at Duke University has shown that microbial populations associated with particular plants differ significantly from one another in terms of microbial species present, ability to utilize various carbon substrates, tolerance to antibiotics, and sensitivity to osmotic and metal stress. The data indicate that plants can influence rhizosphere populations and the biology of free-living bacteria and fungi. Likewise, changes in the soil community can affect plant growth negatively. Spatial simulation models have shown that plant diversity can be maintained or changed depending on the composition of the soil bacterial community. This research may be considered a first step in understanding the linkages between plant and microbial soil communities.

Corn-yield stability in a dynamic environment.

During their flowering and fruiting stages, plants such as maize are susceptible to environmental stresses. Accordingly, maize plants with low rates of floral and fruit abortion in response to drought stress can be expected to have a more stable, predictable annual yield despite unpredictable changes in climate. The plant hormone abscisic acid (ABA) has been implicated as the signal for floral and fruit abortions.

NRI-funded research at Cornell University has shown that kernel abortion in maize is localized to the apical kernels and is related to ABA accumulation in the kernels. Consequently, only the younger apical kernels appear to abort in response to stress.

The research also has shown that the ABA's breakdown to phaseic acid occurs at a higher rate in older, more differentiated basal kernels. ABA appears to induce a quiescent state during mitotic cell division, blocking the cell cycle and kernel development.

Findings such as these could lead to development of a maize genotype that is more tolerant to drought stress. This could result in more predictable crop yields.

Competition and succession. Many factors can contribute to tree and plant species' decline and establishment during vegetation recovery (succession) after timber harvests. A species' decline, however, usually is assumed to result primarily from its displacement by more competitive species—a process known as competitive displacement. Researchers at the University of Washington have used NRI funds to test this assumption by experimentally manipulating *Senecio sylvaticus*—a winter annual that initially dominates sites harvested for wood—and other potentially competing species often found near individual *Senecio* plants.

Surprisingly, the researchers have found that the presence or absence of such species has no significant effect on *Senecio* population dynamics during succession. This counterintuitive result demonstrates that accepted ecological theories must continue to be tested, as unverified assumptions may lead to poor predictions of the recovery of both herbaceous and tree species after timber harvesting.

Outcome 5: Enhanced opportunities for farmers, ranchers, and rural people and communities

Engineering bacteria for fuel ethanol production. Fundamental research at the University of Florida on genetically engineered bacteria is paying off. Decades of NRI-supported study recently came to fruition via a first-of-its-kind commercial factory designed to produce ethanol from cellulose through biomass conversion. The plant, which has the capacity to produce 20 million gallons of ethanol per year, will run initially on bagasse—a residue from sugarcane refining—though it has the flexibility to use other agricultural residues as well.

The \$90 million plant is expected to generate 250 construction jobs, and once completed, more than 60 permanent operational jobs. The establishment of comparable factories throughout the Nation is clearly a possibility if such plants are found to be cost-effective.

The key to the increased competitiveness of this biomass conversion-based operation is the ability of the genetically engineered bacterium *KO¹¹* to produce ethanol from sugar compounds much more efficiently and economically than is possible through yeast-based technologies. Ongoing research, also supported by the NRI, seeks to enhance the process' feasibility further by reducing the cost of the enzymatic breakdown of cellulose into a mixture of simple sugars prior to their fermentation. The bacterial biocatalysts will be engineered to contain genes isolated from other bacteria that can assist in the degradation of the cellulose. At the same time, work is proceeding on production of ethanol-producing bacteria from lignin and other noncellulosic components of plant materials.

Commercially viable guayule rubber. Although many plant varieties are known to produce rubber, the guayule shrub *Perthenium argentatum* is the only domestic source of natural rubber with the potential to become commercially viable. Researchers at the U.S. Naval Research Laboratory are using two approaches to improve guayule rubber.

The first approach utilizes a double network architecture to develop guayule rubber-based elastomers with mechanical properties superior to

those of Hevea rubber. The second approach addresses the barrier performance of guayule rubber. Recent experiments have shown that viral-sized particles can pass through thin layers of this material. The degree to which this permeability arises during latex processing—rather than as a result of intrinsic flaws in the material—is being investigated.

Developing and characterizing exotic corn varieties. Research at Iowa State University is focusing on a number of little-known, underused lines of corn and their potential to produce raw materials, particularly starches and oils, with unique functional properties and high commercial value. The corn lines have been collected in a program designed to rescue and utilize irreplaceable native corn germplasm from South American countries. These diverse, elite accessions have been selected from approximately 12,000 lines.

The research is expected to contribute to U.S. crop diversification, expanded domestic and international markets for corn, and more environmentally sound manufacturing processes. It also is expected to enhance the rural economies involved in specialty grain production by enabling farmers to get higher prices for their corn.

Milk fever in dairy cows. Each year, approximately 6–8 percent of U.S. dairy cows contract milk fever, an important metabolic disorder rendering the animals unable to maintain normal blood levels of calcium at the onset of lactation. Affected cows suffer complete appetite loss, generalized weakness or collapse, and—if left untreated—death.

With NRI support, USDA Agricultural Research Service scientists have demonstrated that contrary to previous belief, dietary calcium is not a major risk factor for milk fever. Instead, the researchers have found that diets high in potassium or sodium actually can *cause* milk fever by increasing blood alkalinity—reducing the cows' ability to use skeletal calcium stores in maintaining normal calcium blood levels. Unexpectedly, increasing dietary calcium does not reverse the disorder.

These findings provide an easily managed feeding approach to the problem of milk fever and already are changing the ways U.S. cows are fed before calving. The findings are expected to be particularly significant for small farmers, as milk fever is an important source of economic loss on small farms.

Dogs and infectious abortion in dairy cattle. A major cause of infectious abortion in dairy cattle is *Neospora caninum*, a protozoan parasite. In California alone, *Neospora* costs dairy producers at least \$35 million annually due to calf abortions.

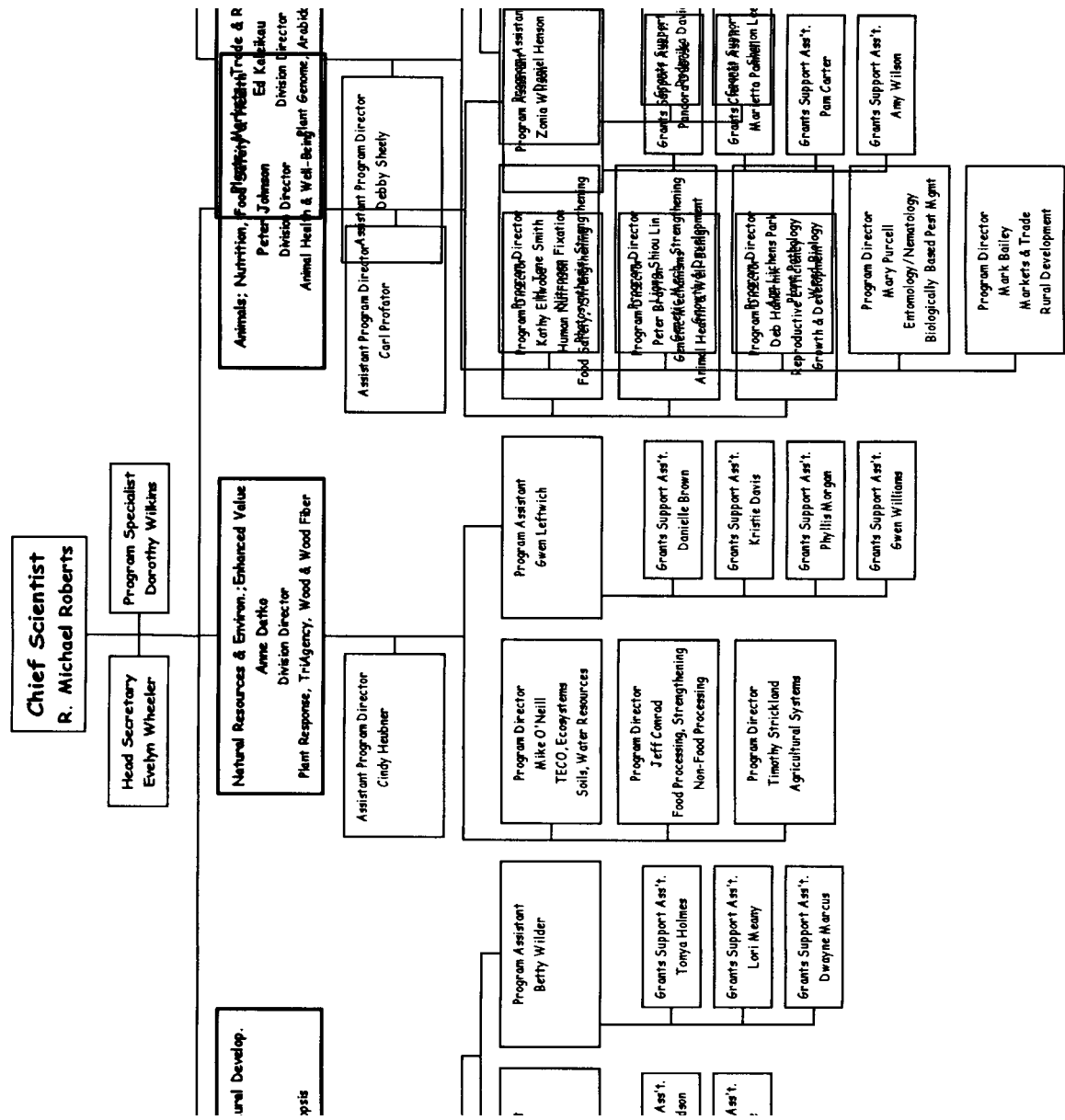
This year, a major advance occurred in the battle to protect the dairy industry from this parasite. NRI-supported researchers at the University of Wyoming, together with researchers from the Agricultural Research Service and Virginia Polytechnic Institute and State University, have demonstrated for the first time that the dog is a definitive host of *Neospora*.

Scientific understanding of the life cycle of this parasite points to practical ways to decrease its impact. For example, farmers should try to keep pet dogs or stray dogs from defecating in dairy feedlots or choice pastures. Fencing could be used to prevent a pregnant cow from eating feces-contaminated feed and then transmitting the parasite to her fetus via the placenta. This simple, science-based recommendation may save farmers millions of dollars of lost income—especially on small farms, where the control measures are easily applied.

Prevention of resistance to *Bacillus thuringiensis* toxin. Recently, crops such as corn, cotton, and broccoli have been genetically altered to contain the *Bacillus thuringiensis* toxin, which provides an environmentally safe means of controlling several caterpillar species. The Diamondback moth—a major pest of cruciferous plants, including broccoli—is the first insect whose caterpillars have evolved resistance to the *Bt* toxin.

Researchers at Cornell University have shown that *Bt*-susceptible moths can be conserved by manipulating the placement of non-*Bt* broccoli plants in the field. This finding, in turn, has led to consideration of further strategies such as substituting other toxins for *Bt* or treating the crop with other environmentally safe insecticides. Alternatively, *Bt* varieties can be used at different times and places in the cropping system. The research has provided a model for several cropping systems that show how the useful life of *Bt* crops can be extended and even maintained by eliminating the onset of resistance in an important insect pest.

Research Initiative Competitive Grants Program



Appendix B

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